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RESEARCH MEMORANDUM

TIME HISTORIES OF LOADS AND DEFORMATIONS ON A B-[illegible]5A AIRPLANE IN TWO AILERON ROLLS

By T. V. Cooney and William A. McGowan

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NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
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SUMMARY

Loads measured on the horizontal tail, vertical tail, and wing and the aeroelastic distortions of elevators, stabilizers, and fuselage of a B-45A airplane in a right and a left roll at a Mach number of 0.60 and an altitude of 15,000 feet are presented. The data are given in time-history form.

INTRODUCTION

A B-45A airplane has been made available to the NACA for a tail-loads investigation. The airplane has been instrumented with strain gages for measurements of the horizontal-tail, vertical-tail, and wing loads and with additional instruments for measurement of the deformation which occurs in the elevators, stabilizers, and fuselage due to aerodynamic and inertia loads.

Some immediate results obtained from the first flight, which was primarily a pilot familiarization and instrument check flight, are presented in this paper. Loads on the horizontal tail, vertical tail, and wing and the structural deformation of stabilizers, elevators, and fuselage during right and left aileron rolls with rudder fixed at an altitude of 15,000 feet and a Mach number of 0.60 are presented in time-history form. Time histories of a steady-flight run, two pull-ups, and a turn have previously been reported in reference 1.

SYMBOLS

Symbols used in this paper are defined as follows:

M	Mach number
h_p	pressure altitude
g	acceleration due to gravity, 32.2 feet per second per second

Up loads on the horizontal stabilizers, elevators, and wing are considered positive. Positive loads on the vertical tail act to the right when looking forward. Other sign conventions used are defined in the figures.

APPARATUS AND TESTS

The airplane used for this investigation is a B-45A (No. 7021). Figure 1 is a three-view drawing of the airplane showing the approximate locations of the load and deflection-measuring devices.

Standard NACA photographic recording instruments are used to measure airspeed and altitude, rolling, pitching, and yawing velocities, sideslip angle, accelerations, control forces, and control positions. The normal, transverse, and longitudinal accelerations are measured at the airplane center of gravity and at fuselage station 714 (approximately the one-quarter chord of the horizontal tail). Measurements of normal accelerations are also made at the midsemispan and tip of both horizontal stabilizers.

The airspeed boom is mounted at the left wing tip with the airspeed head approximately 1 chord length ahead of the leading edge. The results of a flight calibration of the airspeed system for position error and the analysis of available data for a similar installation indicate that Mach number is correct to ±0.01. The sideslip-angle recorder is mounted on a boom extending approximately 1 chord length ahead of the right wing at the tip.

Electrical resistance strain gages are installed on each spar for shear and bending-moment measurements at stations 18 and 14 on the horizontal and vertical tails, respectively, and at station 71 on the wing. In addition, strain gages installed on the elevator and rudder hinges and torque tubes permit measurements of loads and torques on these control surfaces. Twist bars installed in the horizontal stabilizers are used to measure the twist of the stabilizer midsemispan and tip with respect to the root. Control-position transmitters mounted at the root and tip of each elevator are used to measure the elevator twist. The transmitters are wired so as to give no response when the elevator is deflected without twisting. In flight, these measurements refer to twist of the elevator relative to the stabilizer. The right and left elevators are warped at the tip 1.0° and 1.5° trailing edge up, respectively. To obtain total elevator twist, the elevator built-in twist must be added to the flight measurements. Additional control-position transmitters installed at the root of the elevator are used to measure the elevator position. The positions of the tabs, rudder, and ailerons are also measured by control-position transmitters.

An optigraph mounted at the rear spar of the wing (fuselage station 423) is used to record the vertical motion of small lights positioned in the fuselage at the approximate location of the front and rear spars of the horizontal tail (fuselage stations 699 and 759). From this installation a time history of the structural deflection of the rear portion of the fuselage can be obtained. A $\frac{1}{10}$-second time pulse was used to correlate data from all recording instruments.

The data reported herein were obtained in right and left rolls at an altitude of 15,000 feet and $M = 0.60$.

RESULTS AND DISCUSSION

The loads presented are aerodynamic loads. The estimated reading accuracies for the quantities measured are shown in table I.

Presented in figure 2 are time histories of quantities measured in the right roll with the airplane in the clean condition at a Mach number of approximately 0.60 at 15,000 feet. Time histories of measurements made during a left roll at approximately the same altitude and Mach number are shown in figure 3. There was no appreciable variation in airspeed or altitude during either maneuver.

It can be seen from figure 2 that the horizontal-tail-load dissymmetry during a right roll is small, the greatest being 400 pounds more down load on the left tail. The horizontal-tail load varies between 2700 pounds and 3800 pounds in the down direction. Elevator loads are up and small and are less than 400 pounds.

At the start of the run the airplane is in steady 2° left sideslip, and at the time of greatest vertical-tail load the sideslip angle is approximately zero. The maximum rate of roll is 0.46 radian per second. The elevator angles are practically constant at 2.0° down during the maneuver.

The vertical-tail load in the right roll is small. The fin load is 420 pounds to the right at the start of the run with a load of 950 pounds to the left occurring at the time of zero sideslip. The rudder load is to the left throughout the maneuver and is always less than 200 pounds. The rudder angle is zero.

Right and left wing loads are presented. The differential rigging of the ailerons accounts in part for the unsymmetrical appearance of the curves. Maximum total aileron deflection for this maneuver (sum of right and left deflections) is approximately 18°. The maximum total aileron angle available is 45°.

Right and left stabilizers twisted approximately 0.2° nose down while the 0.16-inch tail-down bending of the fuselage at station 699 was reduced 0.03 inch during the roll. Measured twist of the left elevator is 0.75° trailing edge up while the twist measured on the right elevator is 1.5° trailing edge up. The difference in measured twist of right and left elevators in flight may be attributed to the elevator built-in twist.

Figure 3 shows that the greatest horizontal-tail-load dissymmetry in left roll is 750 pounds. At the same time the sideslip angle increased from 1.7° left to 4.4° left. Total horizontal-tail loads increased positively from 3800 pounds down to 2000 pounds down. Elevator loads are less than 400 pounds in the up direction.

The maximum rate of roll in the left roll is 0.56 radian per second. The elevator angles are constant at approximately 2.0° down. The greatest total aileron angle is 23°.

It is seen that the increment in fin load is 1600 pounds with a maximum load to the right of 2000 pounds, which occurs at approximately the time of peak sideslip. The rudder load is small and varies from 100 pounds to the left to 40 pounds to the right. The rudder angle is zero.

The right and left wing loads are approximately symmetrical about a mean which follows the trend of the center-of-gravity normal-acceleration curve. Stabilizer and elevator twists and fuselage deflection are similar to those shown in figure 2. This similarity is to be expected since horizontal-tail loads in both right and left rolls were found to be comparable.

The results obtained indicate that loads on the fin and rudder of the test airplane are small during right and left aileron rolls with rudder fixed at $M = 0.60$ and an altitude of 15,000 feet. The increment in sideslip angle of 2.7° was obtained using a total aileron deflection of approximately one-half the available aileron travel. The greatest load dissymmetry on the horizontal tail occurred during the left roll where the right tail carried 750 pounds more down load than the left.

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REFERENCE

1. Aiken, William S., Jr., and Wiener, Bernard: Time Histories of Horizontal-Tail Loads on a Jet-Powered Bomber Airplane in Four Maneuvers. NACA RM L9H16a, 1949.

TABLE I

ESTIMATED READING ACCURACIES FOR MEASURED QUANTITIES

Center-of-gravity normal acceleration, g units	±0.03
Tail normal acceleration, g units	±0.05
Tail transverse acceleration, g units	±0.01
Elevator positions, deg	±0.25
Aileron positions, deg	±0.10
Rudder positions, deg	±0.10
Sideslip angle, deg	±0.10
Pitching acceleration, radians/sec^2	±0.01
Rolling velocity, radians/sec	±0.008
Yawing velocity, radians/sec	±0.01
Total horizontal-tail aerodynamic load, lb	±160
Stabilizer aerodynamic load, lb (each stabilizer)	±140
Elevator aerodynamic load, lb (each elevator)	±60
Total vertical-tail aerodynamic load, lb	±130
Fin aerodynamic load, lb	±100
Rudder aerodynamic load, lb	±30
Wing aerodynamic load, lb (each wing)	±1000
Stabilizer twist at tip, deg	±0.015
Stabilizer twist at midsemispan, deg	±0.007
Elevator twist (uncorrected for stabilizer twist), deg	±0.07
Fuselage bending deflection, in.	±0.03
Mach number	±0.01

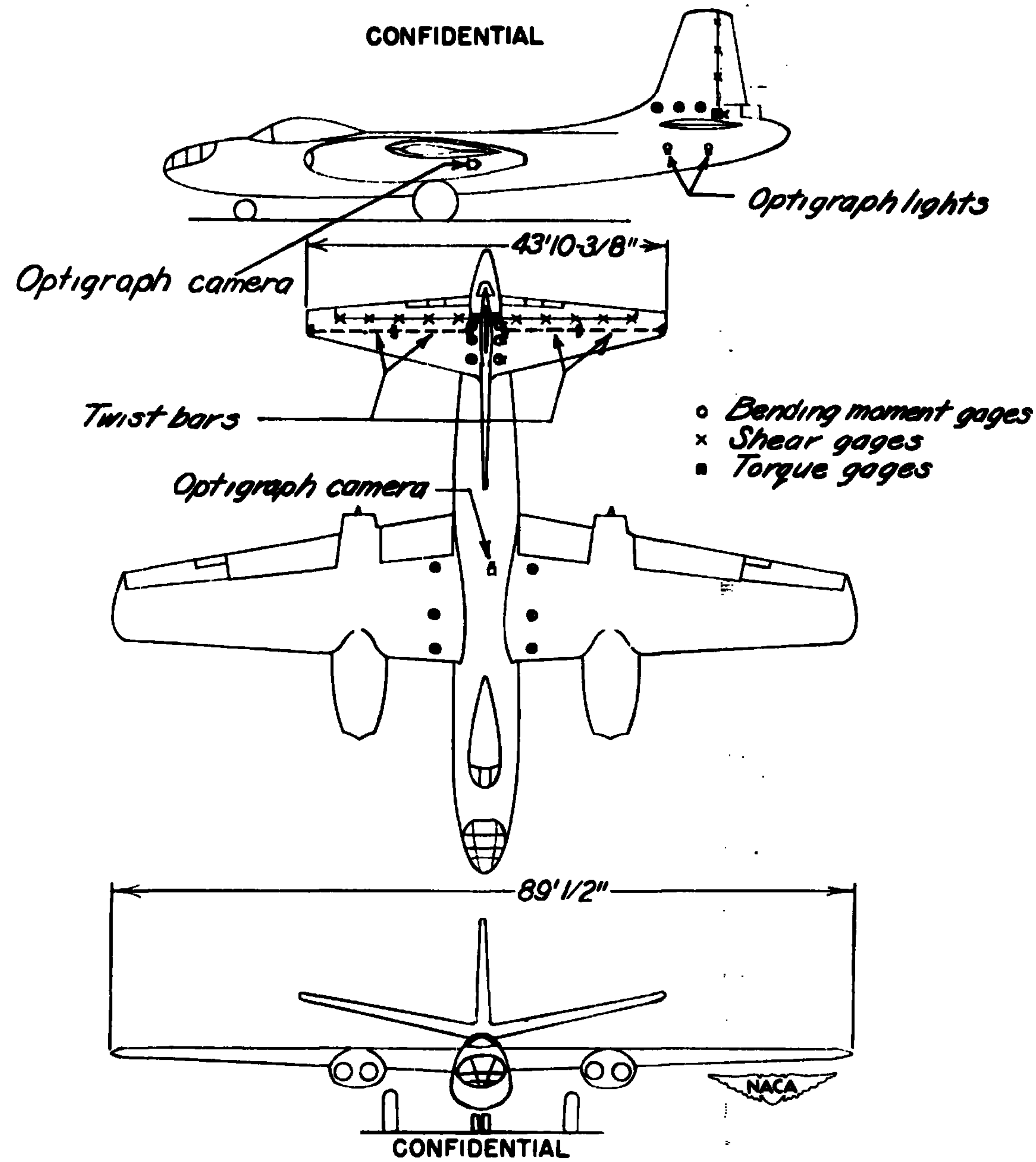

Figure 1.- Three-view drawing of test airplane showing approximate locations of strain-gage bridges and deflection-measuring devices.

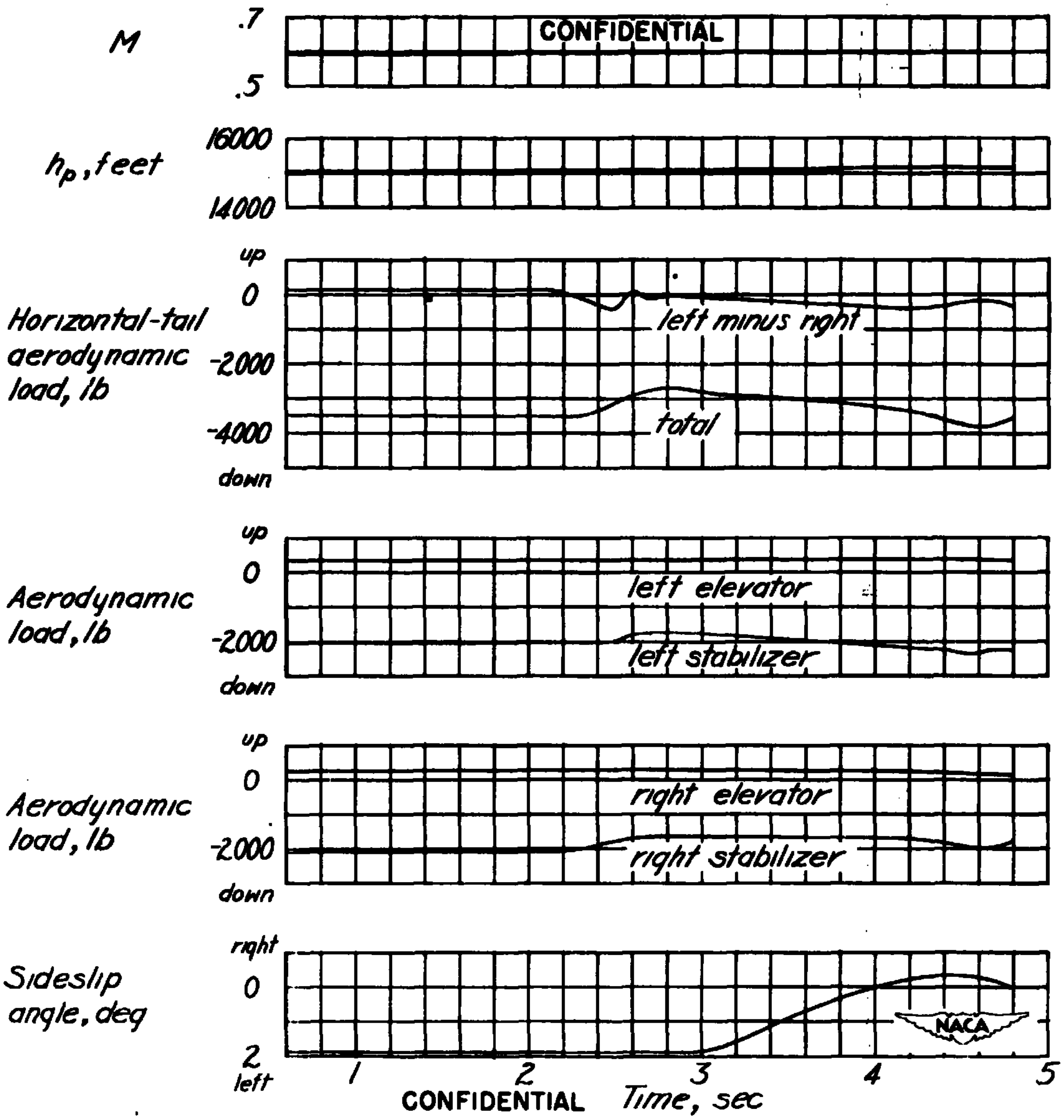

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Figure 2.- Time histories of measured quantities during a right roll. Airplane weight, 61,000 pounds; center of gravity at 28.30 percent mean aerodynamic chord.

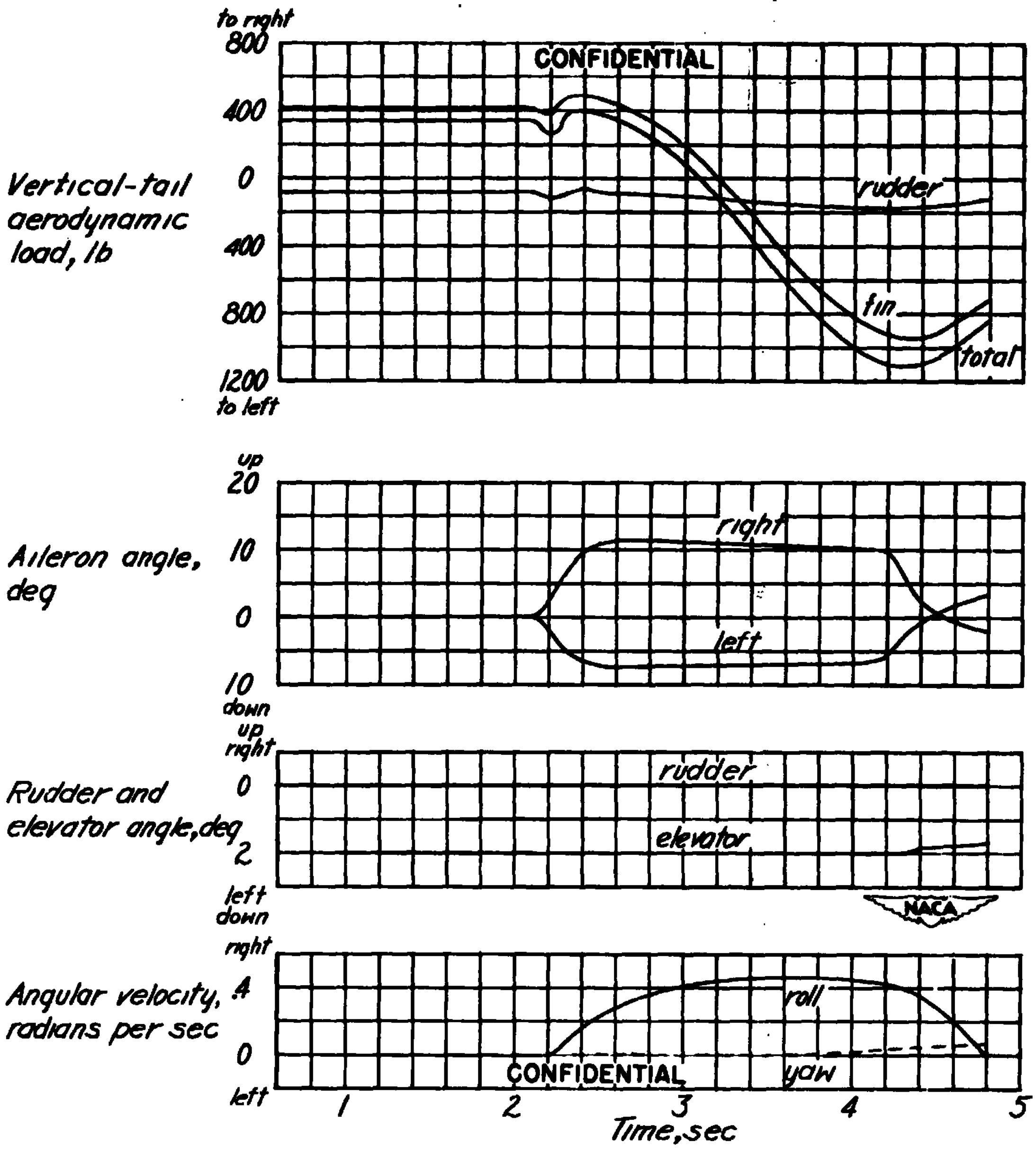

Figure 2.- Continued.

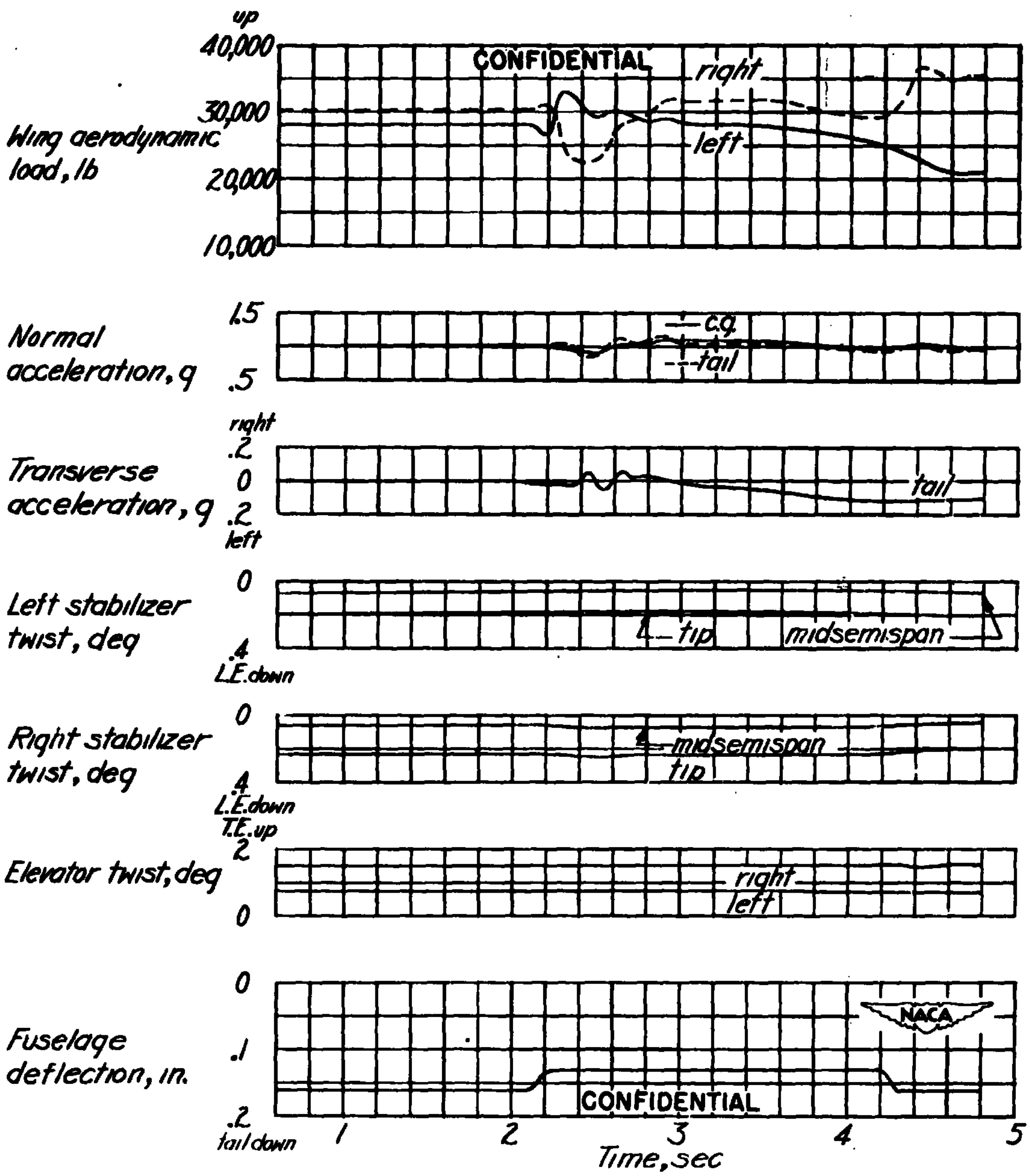

Figure 2.- Concluded.

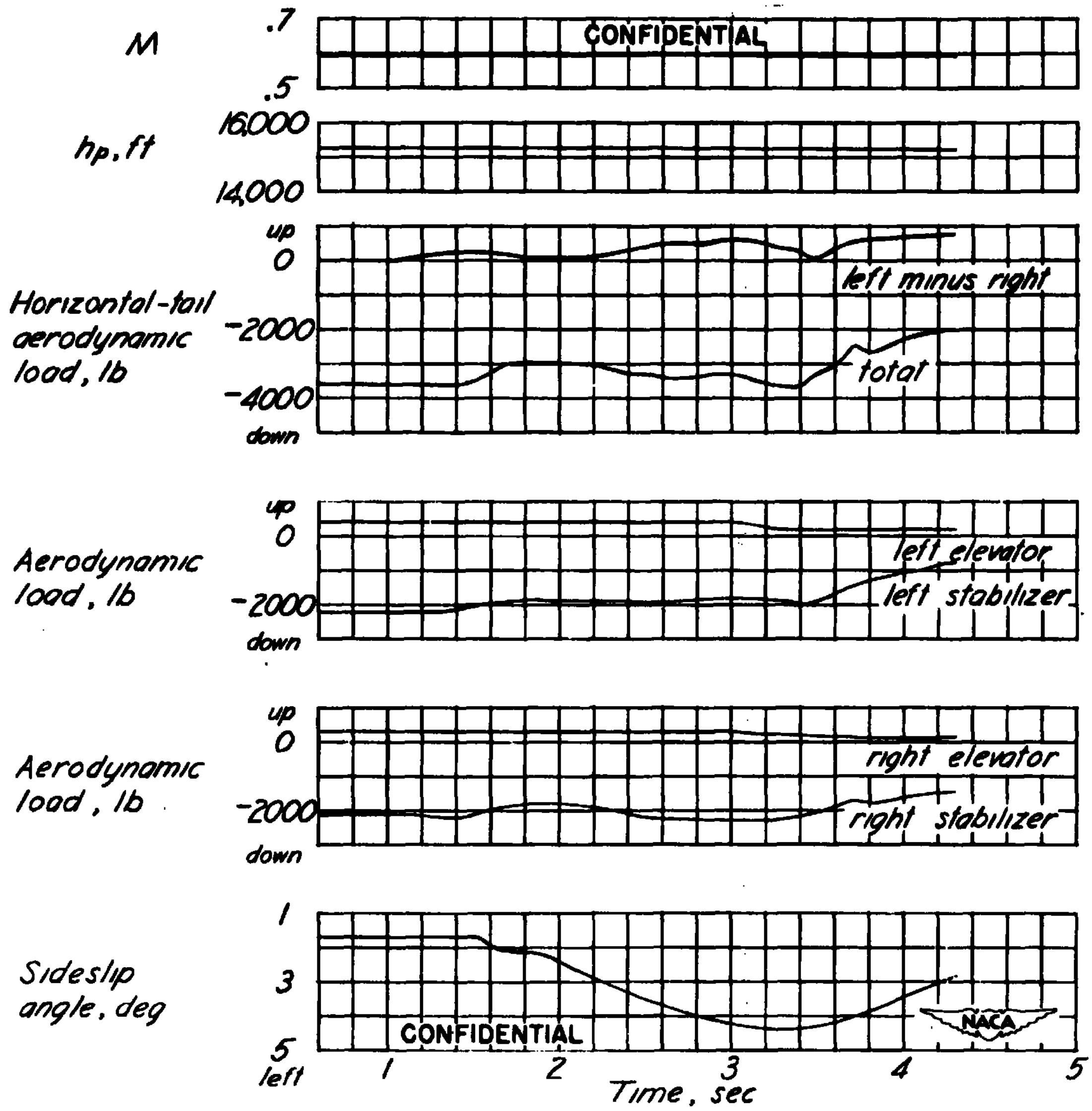

Figure 3.- Time histories of measured quantities during a left roll. Airplane weight, 61,000 pounds; center of gravity at 28.30 percent mean aerodynamic chord.

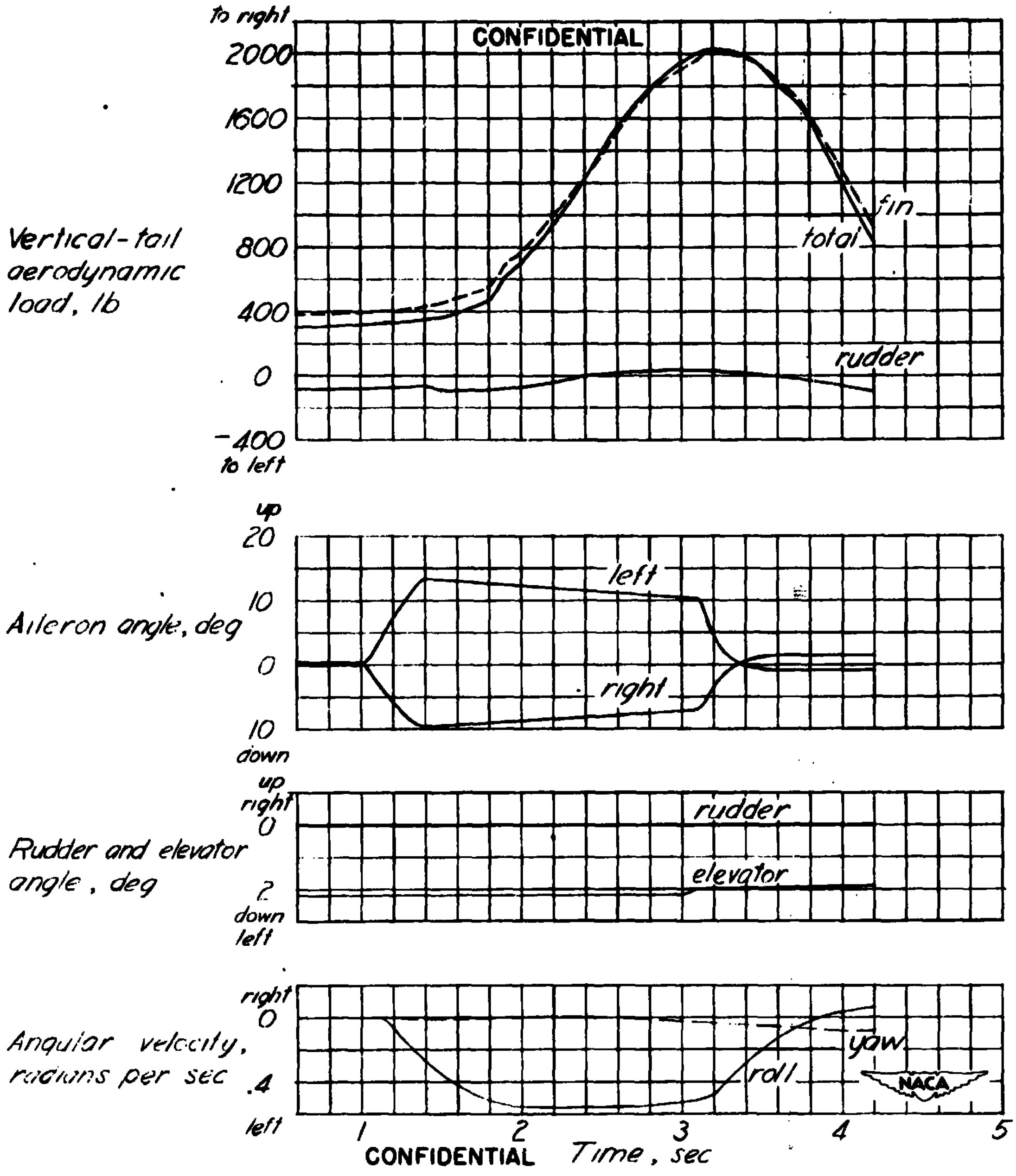

Figure 3.- Continued.

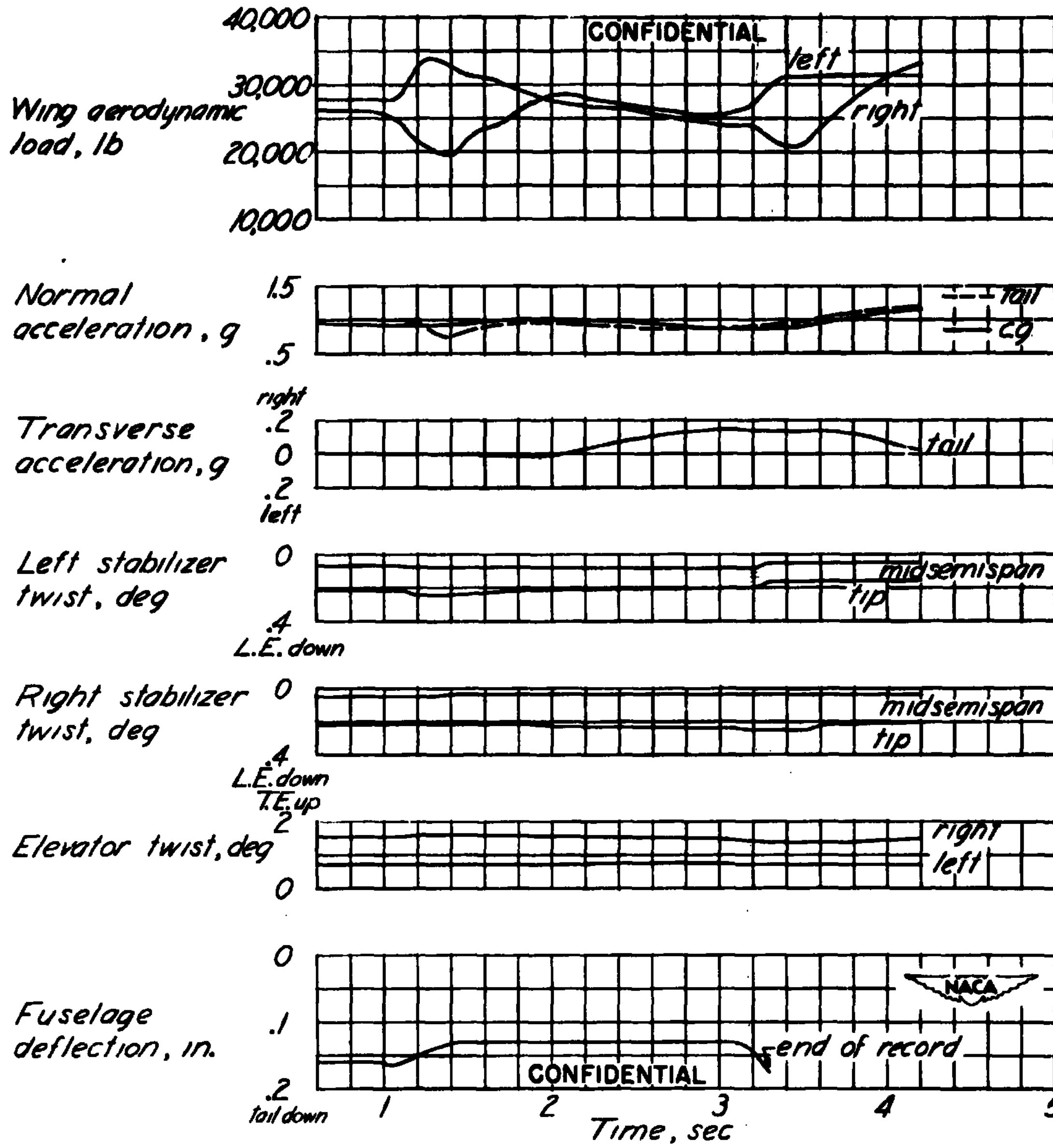

Figure 3.- Concluded.

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Wing-Fuselage Combinations – Airplanes 1.7.1.1.1

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Tail-Wing-Fuselage Combinations – Airplanes 1.7.1.1.3

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Airplanes – Specific Types 1.7.1.2

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Loads, Maneuvering – Wings 4.1.1.1.2

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Loads, Maneuvering – Tail 4.1.1.2.2

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Loads – Aeroelasticity 4.1.1.5

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